Effect of MgTiO/ Pt-BN/ MgTiO underlayer on FePt-X grain size and distributions

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Thin films of highly ordered, tall $L1_0$-FePt with a small grain pitch distance are crucial to the development of heat-assisted magnetic recording (HAMR) media, a key technology in future data storage solutions. Recently, MgTiO and MgTiON is widely used as underlayer for FePt-X magnetic media, which plays crucial role in attaining a correct texture for magnetic media. In this paper we will discuss how the MgTiO/Pt-BN/MgTiO layer influences the microstructure of FePt magnetic layer as well as the texture.

I. Introduction

Heat-assisted magnetic recording (HAMR) technology has emerged as a promising solution for achieving higher data storage densities. A critical aspect of HAMR media design is the optimization of granular film structures to exhibit high grain aspect ratios (h/D > 1.5) and to maintain thermal stability up to approximately 600°C. Among potential materials, ordered $L1_0$-FePt has garnered significant attention due to its high magnetocrystalline anisotropy, which presents a desirable temperature dependence near its Curie transition. Ensuring a high signal-to-noise ratio (SNR) in HAMR applications which requires tall FePt grains, making the selection of a suitable grain boundary material (GBM) essential for attaining aspect ratios exceeding h/D = 1.5. Various amorphous GBMs, including carbon (C), TiO_2, SiO_2, and Cr_2Ox, have been explored to facilitate columnar growth, successfully pushing $L1_0$-FePt grain aspect ratios to approximately 2 [1, 2, and 3]. However, these materials often introduce challenges such as degraded FePt ordering, insufficient thermal stability, or suboptimal in-plane microstructures. Recently, FePt media incorporating boron nitride (BN) has demonstrated high aspect ratios (h/D ≈ 2.5) while maintaining strong thermal stability [4], positioning it as a promising candidate for HAMR media. This paper examines the structural and thermal properties of FePt-X on MTO underlayer and their potential for enhancing HAMR media performance.

II. Experimental

In this study, two FePt-based media stack configurations were deposited using an Anelva sputtering system: (1) glass substrate/buffer layer/seed layer/heat sink layer/MgTiO (MTO)/FePt-X and (2) glass substrate/buffer layer/seed layer/heat sink layer/MTO/Pt-BN(t)/MTO/FePt-X. The thickness of the inserted Pt-BN layer varied from 0 to 2 nm, allowing direct comparison with a control sample. Structural characterization was performed using standard X-ray diffraction (XRD) with a Copper-Kα source to analyze the film texture and order parameter. The microstructure of the samples was evaluated by in-plane and cross sectional transmission electron microscopy (TEM) imaging by using FEI Ticnai 200. Various analytical techniques like bright-field TEM (BF-TEM), high-resolution TEM (HR-TEM), and scanning TEM-high angle annular dark field (STEM-HAADF) are used to probe various factors. The grain size and grain center-to-center pitch distances were analyzed using the in-plane STEM-HAADF images using NIMS image processing analysis software [5]. The magnetic moment (M) vs. field (H) curves of the film samples were measured with a polar Kerr method.

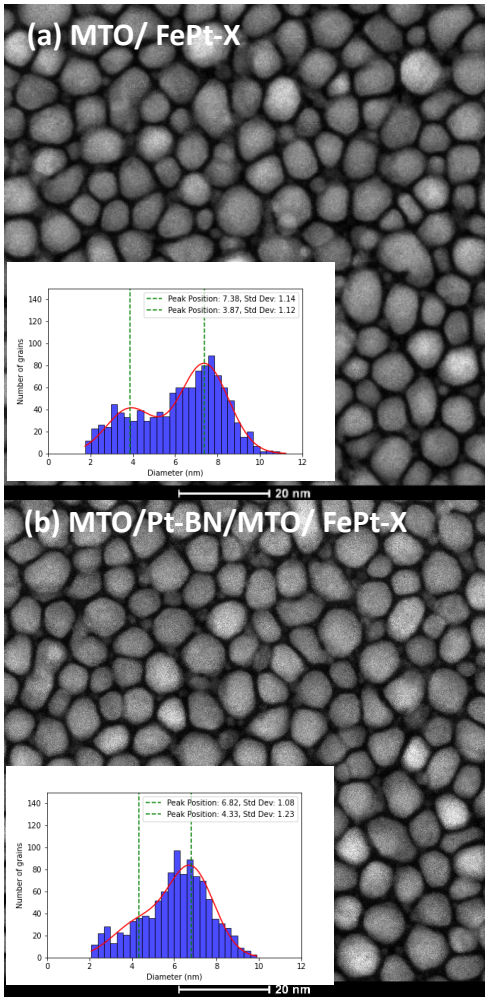

Fig 1. a) HR-STEM micrograph of MTO/FePt-X and b) HR-STEM micrograph of MTO/ Pt-BN/FePt-X (with grain size distributions

III. DISCUSSION

In-plane STEM micrograph shown in Fig. 1 (a) is the sample with MTO/ FePt-X (11 nm), While Fig. 1 (b) shows the MTO/Pt-BN/ MTO FePt-X (11nm). All the samples showed well isolated FePt grains surrounded by segregant. All the films showed a single-layer structure from cross sectional view. The cross-section shows nice 11 nm tall grains which is showed in Fig 2. Fig. 2 shows the cross-sectional view of (a) is the sample with MTO/ FePt-X (11 nm), While (b) shows the MTO/Pt-BN/ MTO FePt-X (11nm). There are no secondary grains are observed, suggest these films have aspect ratio1.5 and 1.6 respectively. Grain size distribution and pitch distance were estimated using NIMS image analysis software on STEM images of these samples. In the case of MTO underlayer we have observed two distinct peaks at 7.3 and 3.8nm in the grain size distribution whereas in the case of MTO/ Pt-BN/ MTO case one prominent peak at 6.83 nm. It suggests the nucleation behavior on the Pt-BN inserted underlayer is very different from control sample. We will discuss in detail how Pt-BN layer insertion modified the underlayer using elemental mapping from TEM analysis and XRD.

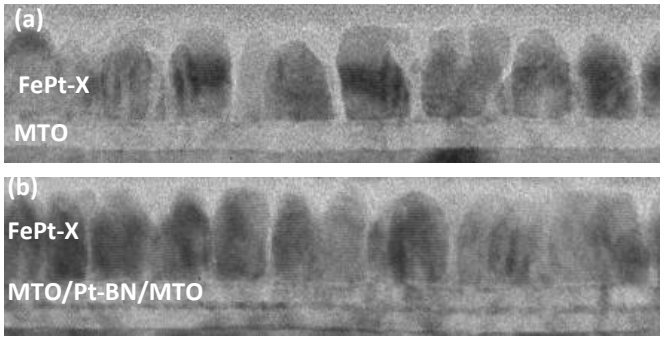

Fig 2. a) BF-TEM micrograph of MTO/FePt-X and b) BF-TEM micrograph of MTO/ Pt-BN/FePt-X

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